Spatial Variations of the Wave, Stress and Wind Fields in the Shoaling Zone

Jielun Sun
Microscale and Mesoscale Meteorology
National Center for Atmospheric Research
Boulder, CO 80307-3000
phone: (303) 497-8994 fax: (303) 497-8171 email: jsun@ucar.edu

Award #: N00014-98-1-0245
http://www.mmm.ucar.edu/science/abl/showex/showex.html

LONG-TERM GOAL

Our long term goals are to improve parameterization of surface fluxes in the coastal zone in the presence of wave growth, shoaling, and internal boundary layer development. These goals include improving the present form of similarity theory used by models to predict surface fluxes and stress over water surfaces, and documenting development of internal boundary layers in the coastal zone that are currently not modelled correctly, particularly in cases of flow of warm air over colder water.

OBJECTIVES

Our objectives are to understand interactions between the atmosphere and surface waves in the coastal zone by analyzing the SHOWEX data, to understand the effect of surface temperature fronts on the atmospheric boundary layer, and to understand the structure of the atmospheric boundary layer under the influence of costal land surfaces.

APPROACH

We will categorize all of the cases to understand atmospheric internal boundary layers, effects of shoaling waves on the interaction between the atmosphere and the sea surface, and effects of sea surface temperature fronts on air-sea interactions and remotely sensed sea surfaces, especially the measurements from the downward looking scatterometer. We will also categorize flights according to wave states to study the influence of the sea surface on the atmosphere. To understand the physics of each item listed above by working with SHOWEX colleagues. To compare our results with the literature to understand all crucial factors in parameterizing air-sea interactions in coastal zones and open oceans. We will focus on aerodynamic roughness length, drag coefficient, Charnok coefficient, and wave age. Eventually, we will try to improve the bulk formulae for numerical models.

WORK COMPLETED

We had a successful SHOWEX field campaign in November-December, 1999. All the instruments on board of the LongEZ aircraft operated successfully. The LongEZ aircraft had 27 flights. The major missions involved studying air-sea interactions as functions of off-shore distance, atmospheric boundary layer structures of internal boundary layers, influences of SST fronts, and spatial variations of surface waves. In addition, we had some joint missions with the SURPAS Twin Otter aircraft to study

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 2000**	2. REPORT TYPE	3. DATES COVERED **00-00-2000 to 00-00-2000**

4. TITLE AND SUBTITLE **Spatial Variations of the Wave, Stress and Wind Fields in the Shoaling Zone**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Microscale and Mesoscale Meteorology,,National Center for Atmospheric Research,,Boulder,,CO, 80307**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
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15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**5**	

air-sea interactions in the coast zone. We also had some special missions to study breaking waves with Ken Melville's camera on board, and to study coherent structures between the atmosphere and SAR images. We have worked with the NOAA group led by Tim Crawford on the LongEZ data processing. The laser data processing is in progress in collaboration with Doug Vandemark at NASA. Our web site (http://www.mmm.ucar.edu/science/abl/showex/showex.html) has been updated to include the information on SHOWEX.

RESULTS

From our two pilot experiments, we have learned the importance of the upstream land influence on air-sea interactions with off-shore flow. During the SHOWEX field campaign, we designed new flight patterns to further investigate the structure of the internal boundary layer and the connection between the internal boundary layer and the air-sea interactions near the coastline.

We have found clear evidence that the large momentum flux observed right off the coastline is mostly attributed to the upstream land influence when the flow is off-shore (Fig.1). The large momentum flux close to the sea surface is part of the internal boundary layer developed at the coastline due to the sharp change of surface type. As the result of the internal boundary layer, there is vertical convergence of momentum flux close to the coastline, which leads to acceleration of the off-shore flow toward the open ocean.

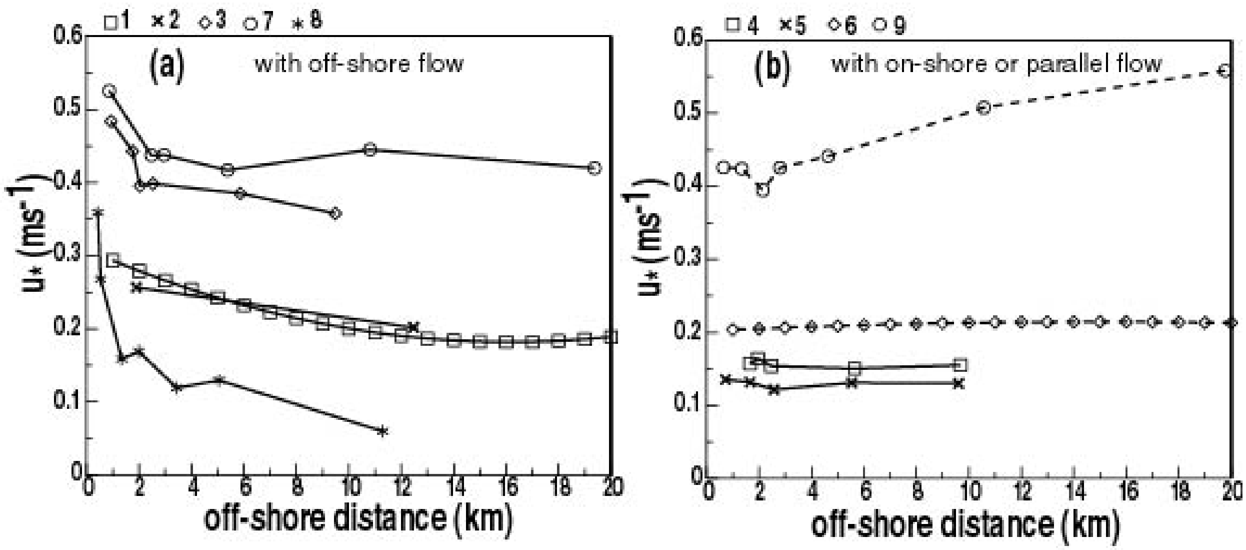

Figure 1: Friction velocity (u_*) as a function of off-shore distance for off-shore (a) and on-shore (b) flow cases.

The independent surface wave measurement from the LongEZ indicates that the sharp decrease of the momentum flux close to the coastline is not associated with young waves generated from the off-shore wind. The surface wave gradually gains energy from the atmosphere, and grows steadily toward the open ocean as indicated by the increase of the significant wave height with off-shore distance (Fig.2). More detailed results can be found in Sun et al. (2000).

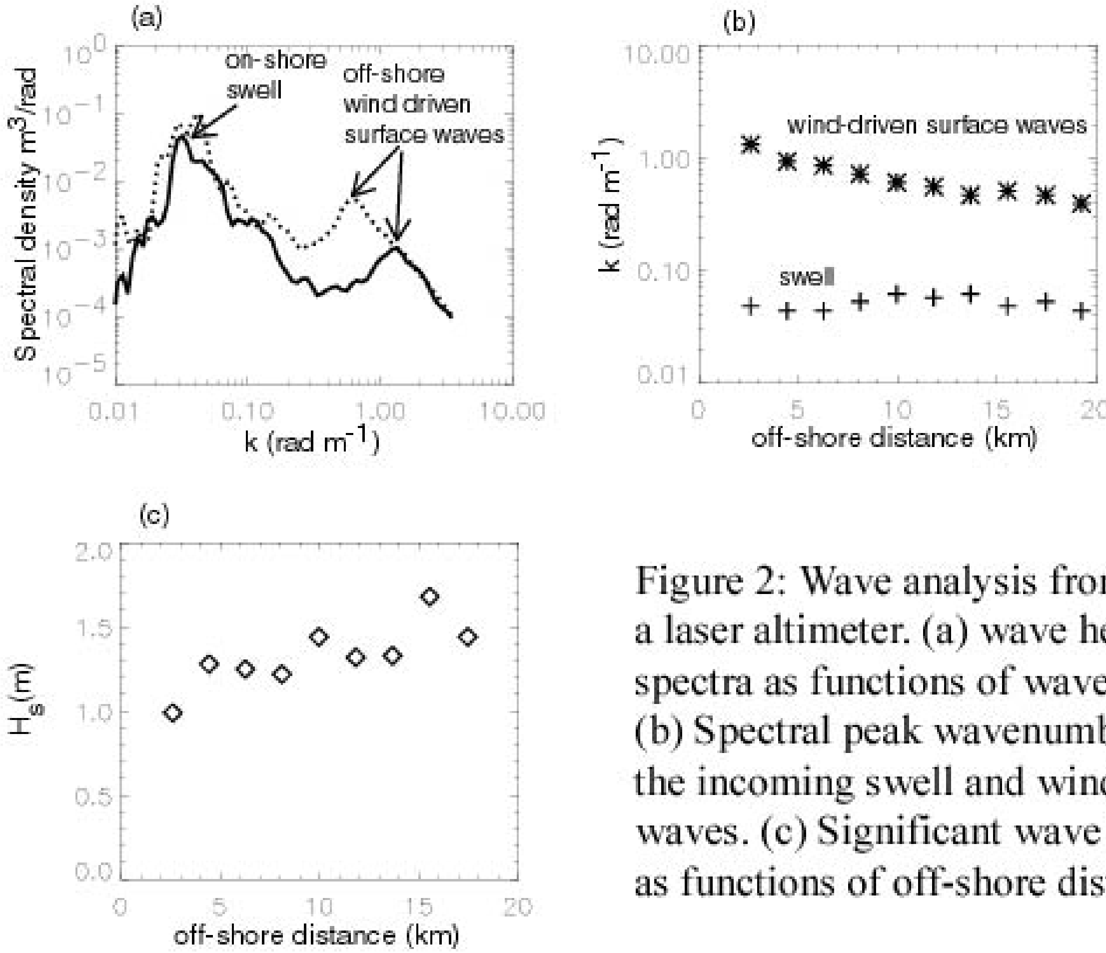

Figure 2: Wave analysis from a laser altimeter. (a) wave height spectra as functions of wavenumber. (b) Spectral peak wavenumbers of the incoming swell and wind-driven waves. (c) Significant wave heights as functions of off-shore distance.

IMPACT/APPLICATION

It is clear that the wave age defined by the momentum transfer may not fully represent the wave state as it was originally designed to do. All the parameters associated with the wave age need to be reexmained. The simultaneous measurements of the atmospheric turbulence and surface waves from the LongEZ aircraft are very important for understanding fundemantal physical interactions between the atmosphere and sea surface waves.

PUBLICATIONS

Vandemark, D., P.D. Mourad, T.L.Crawford, C.A.Vogel, J.Sun, S.A.Bailey, and B. Chapron, 2000: Measured changes in ocean surface roughness due to atmospheric boundary layer rolls. Submitted to J. Geo. Res.

Sun,J., D. Vandemark, L.Mahrt, D.Vicker, T.Crawford, C.Vogel, 2000: Momentum transfer over the coastal zone. Submitted to J. Geo. Res.

Vickers, D., and L. Mahrt, J. Sun, and T. Crawford, 2000: Structure of off-shore flow. Submitted to Mon. Wea. Rev.

Mourad, P.D., D.C.Vandemark, T.L.Crawford, J.Sun, and L.Mahrt, 2000: Similarities and differences in spatial scales of wind forcing of the ocean surface measured in situ, and the ocean's response to that forcing as imaged by SAR. 14th Symposium on Boundary Layer and Turbulence, 7-11 August, 2000, Snowmass, Colorado, USA.

Mourad, P.D., B.A. Walter, T.L.Crawford, J.Sun, and L.Mahrt, 2000: Observations of mesoscale variability in marine surface layer momentum flux events. 14th Symposium on Boundary Layer and Turbulence, 7-11 August, 2000, Snowmass, Colorado, USA

Sun, Jielun, D.Vandemark, L.Mahrt, D.Vickers, T. Crawford, C. Vogel, 2000: Momentum transfer over the coastal zone. 14th Symposium on Boundary Layer and Turbulence, 7-11 August, 2000, Snowmass, Colorado, USA.